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ABSTRACT

This document contains six papers presented at a conference on Science and Public Policy in the American University, held at Indiana University, March 20-22, 1968. The purpose of the conference was to report results of curriculum development in science and to examine issues and problems of science policy. All six papers included address topics of science curriculum development and/or science and public policy. (SL)

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SCIENCE AND PUBLIC POLICY IN THE AMERICAN UNIVERSITY

PAPERS DELIVERED AT A CONFERENCE SPONSORED BY INDIANA UNIVERSITY AND PURDUE UNIVERSITY

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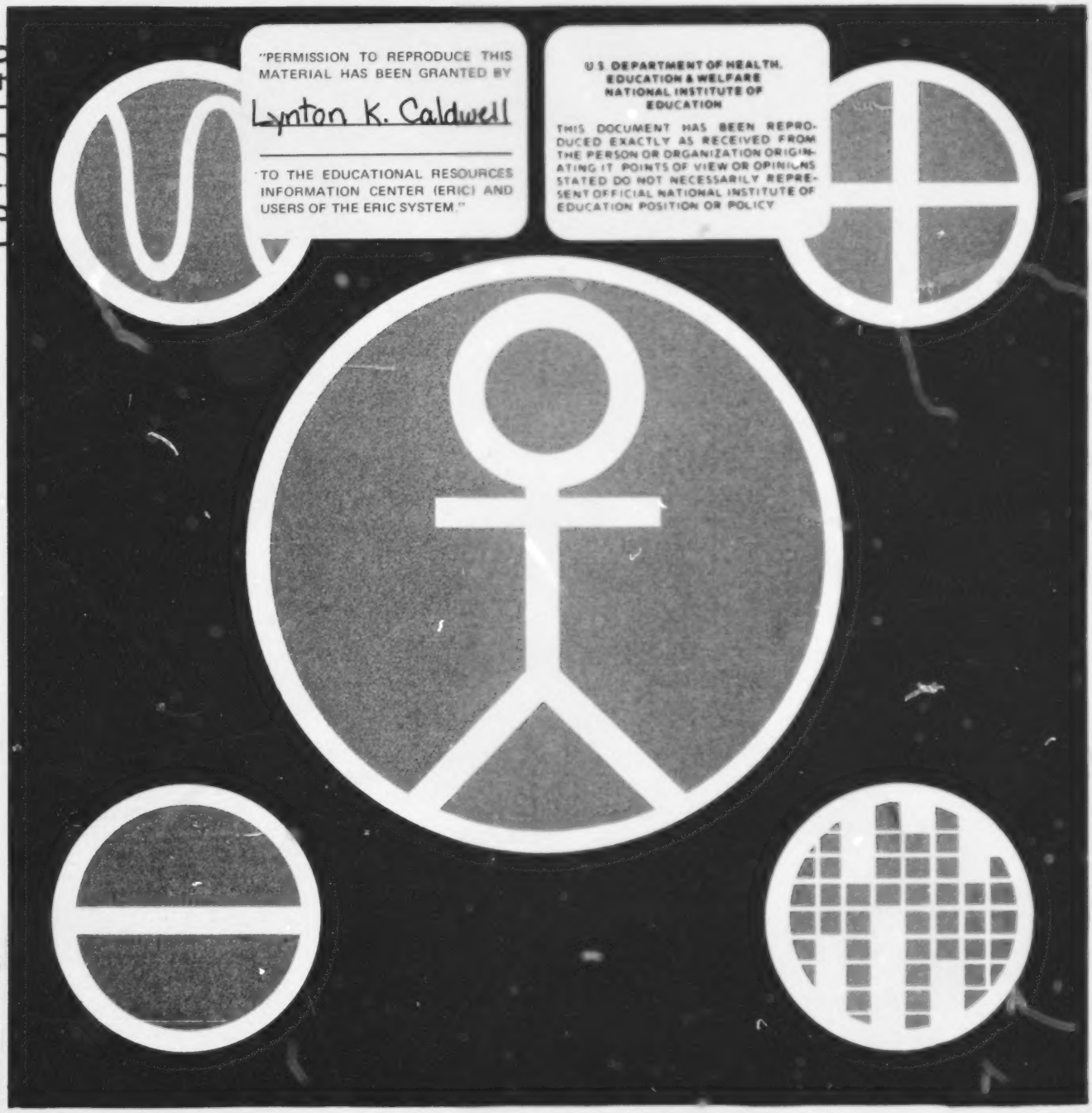

SCIENCE AND PUBLIC POLICY IN THE AMERICAN UNIVERSITY

Papers Delivered At A
Conference Sponsored By
Indiana University And
Purdue University And
Assisted By The
National Science Foundation

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with the assistance of
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Indiana University
Program in the Public Administration
of Science and Technology
Department of Government

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PREFACE

The six papers assembled in this collection were prepared for a conference held at Indiana University on March 20-22, 1968, and sponsored jointly by Indiana University and Purdue University. The purpose of the conference was to report the results of a two-year study of university curriculum development in science and public policy undertaken by the sponsoring universities under a grant from the National Science Foundation. Attendance at the conference was by invitation to representatives of twenty-two universities, located chiefly in the Middle West, which had indicated an interest in the development of research and teaching in the newly developing academic field of science and public policy.

The scope of the conference was broader than the experience of the sponsoring universities. Although their experience was reported to the conference, a broader range of issues was introduced and discussed. The participation of Senator Fred Harris, Chairman of the Senate Subcommittee on Government Research and of Philip Yeager of the staff of the House of Representatives Committee on Science and Astronautics brought issues and problems of science policy directly before the conference. The contributions of these representatives of Congressional policy-making for science and technology provide the opening and closing papers of this collection as they did at the conference. The four intervening papers were prepared by university representatives who, each in his own way, has done pioneering work in the development of science and public policy studies in American universities.

As the conference discussions were discursive, wide-ranging, and inevitably occasionally repetitive, no attempt was made to reconstruct a transcript of actual

deliberations. The sessions were "working sessions" and were not intended to be productive of polished discourse. But the papers, prepared to help structure the conference and bring to it some of the reality of the science policy process, could be made available to a wider audience. Requests for the papers were received from institutions unable to send representatives to the conference and from numbers of other persons interested in this general subject matter. The sponsoring universities and the National Science Foundation therefore agreed that an inexpensive reproduction of the papers for general circulation would be useful and consistent with the objectives of the conference.

On behalf of the authors, the sponsors would like to make it clear to the readers that these papers, although serious in purpose and substance, are not presented as products of scholarly research. They are largely distillations of experience. Some of them, notably the contribution of Eugene B. Skolnikoff, report the results of original investigation. For the most part, however, they are deliberately subjective and informal. This in no way diminishes their value for the purpose for which they were intended and for which they are now more generally available. They represent shared insight and experience rather than outcomes of scientific research.

In a very real sense the remarks of Senator Harris at the opening of the conference may be described as the invocation of a concerned citizen--a call for action by the universities to respond more effectively to the need for a better understanding of human behavior. He called for the kind of national attention to the social sciences that the physical sciences have received since World War II. The question of whether a Social Science Foundation would be the most promising avenue to this objective was discussed only briefly at the conference. The possible advantages of a funding agency for public

policy studies was recognized. There was some doubt as to the readiness of the scientific community generally to accept policy-oriented research as "science," or to agree that anyone other than persons properly accredited as scientists could be legitimate students of science policy. Nevertheless, many participants felt that the study of public policy for science and technology required the interaction of scholars in all fields of science, and that, at least for the present, the National Science Foundation was the logical forum in which this field of policy studies should be considered.

Dr. David Heebink of the Office of Planning and Policy Studies described the efforts of the National Science Foundation to assist the universities in the development of centers for the study of science and public policy. He told the conference that the Foundation was definitely committed to assistance in this area, although the extent of assistance was, of course, contingent on budgetary considerations.

The conference did not attempt to reach findings or recommendations. It was not directed toward this kind of outcome. Certain conclusions regarding the development of science and public policy in American universities were, however, implicit in the discussions and were often reinforced by the papers. In summary, these conclusions were:

1. The study of public policy and administration relating to science and technology is certain to became increasingly important in the universities in the years ahead.

2. The interest in science policy studies is much greater than the action in American universities, and for two reasons:

a. the study of science policy has no "natural" home among the disciplines--academic organization does not generally facilitate its study, and

b. money to support teaching and research in science and public policy has been severely limited (with the notable exceptions of Columbia University and Harvard University).

3. University programs in science, technology and public policy require multi-disciplinary involvement. There are various ways to obtain this involvement, however, and no single pattern of program organization seems equally appropriate to all universities.

4. The successful direction and development of a program of study does seem to require some formalization of responsibility and a clear indication of legitimate institutional status and support. Nearly all of the universities that have taken the lead in this area of study have established centers, institutes or programs for this purpose.

5. The most urgent financial needs are for

a. financial assistance to pre and post doctoral students to pursue studies in the field. The multi-disciplinary character of science policy studies tends to place them outside the boundaries of eligibility for assistantships or fellowships in the conventional disciplines.

b. grants for research that cross disciplinary lines and are likely to be given low priority by discipline-oriented review committees.

c. assistance for studies that help to organize subject matter and concepts in the emerging field. Bibliographical studies are important at this stage in the development of the field. (The conference noted the completion of the first volume of a bibliography on science technology and public policy prepared at Indiana University under a contract with the National Science Foundation).

6. Consistent moral and financial support for university programs in science, technology and public policy by governmental agencies and foundations and especially by the National Science Foundation

The editors would like to acknowledge the assistance of the National Science Foundation in the funding of the conference and the publication of these papers. Special appreciation is owed to Miss M. J. Callanan who has been the representative of the National Science Foundation principally concerned with this project since its inception.

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INTRODUCTION

PUBLIC NEEDS AND UNIVERSITY RESPONSIBILITIES IN THE DEVELOPMENT OF PUBLIC POLICY FOR SCIENCE AND TECHNOLOGY

BY SENATOR FRED HARRIS

It is hard to overestimate the importance in today's world of public understanding of the meaning and importance of science and technology. It is equally difficult to overemphasize the need for men and women in government with this understanding. Unfortunately their numbers are too few and herein lies a responsibility that our universities ought to see.

People who really understand government and also know something about science and technology are very difficult to find. Not long ago I was lucky enough to find one of these scarce individuals for our subcommittee staff in the Senate. He had a bachelor's degree in science, a master's degree in the history of science from Harvard, and a Ph.D. in political science from Georgetown. He had been working in the Library of Congress in the Science Policy Division on the Legislative Reference Service under Edward Wenk, Jr. (who is another person who cuts across disciplinary lines). The difficulty in finding people like this--and the rapidly growing need for their services in government--points out the importance of university training in science, technology and public policy.

I first became aware of the critical importance of multidisciplinary training in science, technology and public policy when the Subcommittee on Government Research began to look

into the broad question of how the government develops policies for research and development. Actually, at first, our interest was even broader than this. To deal with the problems of research in context, we needed to know how the government of the United States actually makes policy in relation to the more inclusive fields of science and technology. We then had to ask ourselves another question, which we found was just as difficult to answer: How should it make policy? This led us to an appreciation of our need for people capable of assisting government in this difficult and increasingly important phase of the public policy process.

Returning to the question of how the government of the United States presently makes policy for science and technology, we came to believe that it makes it accidentially. There is something that might be called a national science policy, but it is a conglomeration of decisions made on a fragmented basis. Cumulatively, its pieces add up to some kind of overall national policy, but it is mostly a product of inadvertence and accident.

Looking first at the policymaking structure of the Executive Department we find that, despite the unifying role of the President, it is very much fragmented. There has been an attempt to establish a more coherent national policy with the creation--by executive order, not by Congressional act--of the Office of Science and Technology in the Executive Office of the President. This is an advance in the right direction, and that office, headed by an excellent man, Dr. Donald Hornig, has done a good job. However, we still need an office with the power and prestige which only legislative authorization could give it. The O.S.T. was created by the Executive, and is responsible directly to the White House, without any responsibilities to report to Congress, or to make public statements or appearances except in

support of the President's previously established policy. It is an agent of Presidential policy, which is sometimes less than national policy.

The National Science Foundation is the most visible of the government agencies which have to do with science policy in the federal government. But actually, it deals with a rather small portion of the massive funds which the federal government spends for science and technology and its policymaking activities are relatively slight. The largest portion of the money is spent by the Atomic Energy Commission, the Department of Defense, the National Aeronautics and Space Administration, and the National Institutes of Health. But if this dispersal of authority is the case in the executive departments and agencies, it is even more the case in the Congress.

Theoretically, the Appropriations Committees in the Senate and the House have government-wide jurisdiction, so that, in the review and justification of the overall budget, they would have to make some choices in expenditures--for example, whether to put money in supersonic transport as opposed to cancer research. That operates, however, only in theory because the Appropriations Committee is a large committee—the largest in both the Senate and the House. It has enormous burdens in trying to sort out these choices. Moreover, it actually functions through its subcommittees, and these subcommittees, by and large, follow executive agency priorities. The Congress does not get to make many real choices. It is not organized to make a considered assessment of priorities in relation to national needs. Instead, it usually can only react affirmatively or negatively to specific issues. The person who sits on the subcommittee, say, for NASA, becomes an expert on NASA's budget.

Similarly if he served on a subcommittee which had jurisdiction over the National Institutes of Health he would become familiar with their budgets, but his information would not help him to decide whether we need more space technology and less health research, or whether we should spend more, or less, on forestry. The person who sits on the Appropriations Subcommittee becomes an expert in the Subcommittee's fields, but not on the public budget generally. Therefore neither of the committees on appropriations are equipped to look at the broad spectrum of expenditures or to consider the question of priorities.

At the present, priority decisions are made in the Bureau of the Budget, and I am not sure that they are made with the proper justification. A lot of facts are missing in the decision-making process. There are, however, areas of great merit and strength in our science policy system. As someone once said, "if you get enough basketballs bouncing on the court, one or two are liable to go into the basket." There is merit in the feeling that we do not want a science czar who sits down and decides how government is going to spend its money this year for science and technology. We have seen how the Soviet Union in some fields, using a very rational and controlled decision-making system--although this is somewhat of an oversimplification--has been remarkably retarded from time to time. People who have visited with their counterparts in a scientific discipline in the Soviet Union report that the Soviets are very much interested in how the pluralistic American system works. The Soviet science policy system has undergone repeated reorganization during the last decade, which suggests that the Soviets have not as yet found a satisfying answer to this problem.

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The second thing we can say, in addition to acknowledging that we don't want a science czar, is that we have got to continue to be very much interested in basic research. Any time we speak of a goals-oriented policy, or a science policy at all, we scare a lot of people. They think that all the basic research funds are going to dry up, and that the emphasis will be only on technology, or on application and development. Nobody wants to go to this extreme, and certainly our subcommittee does not want to. Obviously, we cannot make any progress at all unless we continue to expand our basic reservoir of knowledge at an accelerated rate. Not only must we continue what we are doing in basic research, but we must increasingly expand it.

When the conflict in Vietnam is over, a great deal of money is going to be freed. The President is going to have to make some decisions about what to do with this money. And one of the things to be decided on is what to do in the science and technology fields, especially in research and development. At the present time, in our system, the President cannot have all the needed facts at his disposal when making a decision. One thing he needs to know--not necessarily the most important--is what sort of economic impact will occur as a result of various kinds of science expenditures. What sort of growth in the Gross National Product will we get from each kind of expenditure, for example? More importantly, he needs to know what sort of effect these expenditures would have on the enormous human problems we have in this country. I don't think our present decision-making mechanisms permit us to make the kind of rational, conscious policy determinations we should be able to make.

Until I am sure that we have got something better, however, I do not want to supplant

the diverse multiplicity of approaches that we have developed to new knowledge. Disorganized as it appears to be, this method has worked spectacularly well in many ways. Yet we must consider that it has also worked spectacularly poorly in many other ways. It has worked poorly, for example, in the field of the social sciences. The social sciences never had a Manhattan Project or anything like Sputnik which would have meant increased visibility and public attention. Attention means, among other things, money. Since 1945 we have had that attention in the natural and physical sciences, and, as a result, man can accomplish almost anything today by pushing a button, not excluding the destruction of the world. We know quite a lot about the button and about the machine it activates, but we know very little more than we did about the man who pushes the button. We are never going to get that knowledge without giving the social sciences what they need—the attention that they would get if we established a National Social Sciences Foundation.

Let us consider the broad range of social legislation that we have enacted in recent years--for example, in the war on poverty. The war on poverty has suffered from two kinds of shortages. It could have survived one, but two shortages have made its progress extremely difficult. One has been a shortage of dedicated people, of people who are compassionate, knowledgeable, dedicated, and willing to try to cope with these tremendously difficult human problems that are involved in poverty--cultural deprivation, racial prejudice, and so forth. Such people are always in short supply. The second and more debilitating shortage is the inadequacy of knowledge and methodology. A man who is not expecially strongly dedicated to a task can do a very good job if it can be explained to him just exactly what his job is. We need to say: "Your job is to go out there to help a man who has been out of work, who has suffered some kind of deep psychological damage during

the long period when he was looking for work, who has lost some of the armor-plating that most of us have that allows us to suffer rebuffs and continue--and here are precisely the steps that you must follow to assist that man. Here is the kind of psychological damage that he has suffered, and here are the steps that you can take to rebuild his motivation and his self-confidence." The mere offering of opportunity to a man like that does not necessarily bring him back into society. But we don't even know how to do that effectively. We are suffering from a crisis of ignorance in relation to our basic social needs.

There are a great many things we don't know about human beings, and we really hadn't realized that we didn't know them until we got to the critical stage that we have now reached. In the 1930's we didn't have to worry so much about what we didn't know, because things were so bad that any well-intentioned act of government seemed to help somehow. But now we are building a permanent poverty class in this country. At a time when we are more affluent than ever before, we are trapping people in poverty with no chance of escape. We are systematically destroying many children in poverty-stricken areas, and we do not know how to change the situation. We know some things that are rather obvious, but if we knew more, we could do a better job without having to experiment as much. If we really made carefully weighed public decisions about science and research and development policies, we would certainly take a greater interest in the social sciences.

The same is true in the medical field. Here is another illustration of the shortcomings of our present system of establishing science policy. The United Stated of America, with a Gross National Product soaring above 800 million dollars, now ranks twelfth among

industrial nations in the world in infant mortality. Japan, for example, ranked above the United States last year in this respect. We have been holding some hearings this past year in our Subcommittee on Government Research on the application, development, and use of bio-medical knowledge. This year we are holding hearings on the ethical, moral, legal, and economic questions involved in medical advances. Some very difficult public policy questions are involved in heart transplants, genetic engineering and many other developments in bio-medical science. We are at the present time on the threshold of being able to preserve living tissue. Very soon we are going to be in a position where tissue can be kept for quite some time. We won't have to wait for that until 1984; it is nearly upon us now, and these are questions that society might as well commence to consider, because they are going to have to be considered before very much longer. There is a great deal of mysticism bound up in present-day thinking about the human body after it is dead. Perhaps we are not thinking very realistically or even ethically about these problems. These are the kinds of things that government policy ought to look at before, and not after, the fact.

It is estimated that over 7,700 people could be saved this year by kidney transplants, or by use of an artificial kidney. There are terrible moral questions involved here for policy-makers. And, whether we know they exist or not, these questions are just as terrible for us because today we haven't any right not to know that they exist. Infant mortality is double where poor people live as compared with the affluent suburbs. People are dying a few blocks away from some of the finest medical facilities in the world in this, the richest and most powerful country in the world. A Negro woman in

this country is seven times more likely to die during pregnancy or immediately following delivery; a Negro child from one month to three years is three times more likely to die than a white child. We are confronted with some difficult judgments now, and we must begin to face up to our responsibilities. The situation is bad enough in terms of the present expected life span. What sort of problems are we going to have as life becomes longer for people? We have come to the place where our rivers are not fit for fish-not to mention human beings-and the air that we breathe in most of our cities is unclean and is hazardous to health. These are things that our policy-makers for science and technology simply must face up to.

Now we come to the critical question of who is going to face up to these things. It is not going to be done by politicians alone, and it is not going to be done by scientists alone. We are going to have to find some way, first, of producing people who can walk back and forth between both camps and, second, of creating the kind of language which will enable those in the separate camps to speak to each other. "Interdisciplinary" and "multidisciplinary" are probably the key words of our age. The universities need to do much more to bridge the gaps among the disciplines and to make it respectable for scholars to specialize in synthesis and breadth as well as in reductionism and depth. In the field of bio-medical engineering, for example, we ought to have a National Institute of Bio-engineering in the National Institutes of Health. The engineers right now can do many things that doctors would like to do if only they knew that it were possible. We have a crisis in health in this country and it is going to get worse. We are not able to bring all this new technology in the field of engineering to bear on these medical problems if an

engineer is going to be the subordinate of a doctor-certainly not if he is going to be treated like a mechanic and not allowed in on the decision-making process. There are other exciting fields for the engineer, and he can obtain research funds about as easily as the medical people. He will do exactly that, and not get involved in some kind of multidisciplinary effort unless he attains the status of equal partner in the medical field. This is very difficult because people in the medical field see their relationship with the patient as one that takes precedence over all other relationships, and perhaps they are correct. But there ought to be a way to distinguish among these different relationships and to share the prestige more equitably among the partners in this endeavor.

Dr. Michael De Bakey, the heart surgeon, was dealing primarily with engineering problems; but he could not find engineers who knew enough about the engineering problems of doctors or doctors who knew enough about engineering to give him the technical support that his work required. Finally, he had to organize and develop these special talents together in one group at Houston. His group worked for a long time by trial and error in order to discover a substance from which an artificial heart could be made. When they eventually found the material, it was a plastic which had been long in existence. We really can't afford this trial and error method anymore. We can't afford to have people engaged in years of experimentation only to have someone say at the end, "Well, my goodness, I had known that all along; I hadn't any idea you were interested."

Eventually, this all becomes a problem of public administration. How do you put together a giant kind of project or a much larger kind of project than we are used to talking about? How do you administer it? How do you bring yourself to consider the

philosophical implications and the social science implications of what is being done? What happens, for instance, psychologically, to that person who depends, for his life, upon the artificial kidney? How do we allocate responsibility for preventing the pollution of air and water and how do we apportion the costs?

These are the questions, of a multidisciplinary kind, that we are going to have to answer as we move with these fantastic advances that we have made. The dialogue that the people in the academic community involved with these issues can help to establish between people who are compartmentalized into rigid disciplines in the university, in industry, or in politics is extremely important. All of these things cut across disciplinary divisions, and no one can make a separate decision of the greatest value to society without knowing something about what many other people also know. These problems of choice, of evaluated alternatives of public policy and administration, must be focused and channeled in the university. The universities must serve the larger community, and must do so to a larger extent than we have heretofore expected. The universities are the place where rigid disciplines originated, and they are going to have to be the place where they commence to breakdown--not in some "take a psychologist to lunch" kind of thing--but in a permanent focus on common problems of interest, of mutual interest, to those involved. I think we can do it. I am reminded of what George Bernard Shaw once said, "Some men see things as they are and ask why. I see things as they have never been and ask why not." And I think that is what people in the institutions of higher education around this country have got to do.

WHY SCIENCE AND PUBLIC POLICY?

By Don E. Kash

Of the several reasons for the development of what one student has called the "non-field" of science and public policy, one stands out. This is a growing sense of something between frustration and fear. As Secretary of Labor Wirtz put it: "What we are doing really right now is flying the most powerful economic engine in the history of mankind, and I mean to include all of our scientific and technological developments, and we are flying it by luck, by instinct, with almost no instruments at all in the cockpit. . . . I am not sure that on this basis we are going to be able to keep it up, as social engineers, flying this blind with the amount of technological development which is being brought about."[1] In summary, then, science and public policy is an outgrowth of a growing sense that our technological society is creating more costs and fewer benefits in terms of social variables than should be the case.

There is clearly a certain lack of precision in the label "science and public policy," yet those people working in the area share certain basic assumptions. First in importance is the assumption that those activities which are referred to as science and technology are major causes in the evolution and modification of political and social processes and institutions. It is my personal belief that at some point in the future we will all view the role of science and technology as similar to that of the economy in

terms of its impact on society. Science and technology are not only causing major changes in the complexity and substantive nature of our society, but they are also rapidly collapsing the timespan of substantive change. It seems clear then, that if we are to understand our society, focusing on science and technology provides one of the better handles.

The public policy end of our label for this non-field results from the fact that the vast majority of our science and technology is supported by the federal government. In absolute numbers the level of dollar support has now passed the 17 billion mark. It would probably be reasonable to expect that some scholars would take this as an area of policy study for the simple reason that it is a substantial part of total federal activity. The particular intensity of interest is reinforced by a belief that of all the areas of federal expenditure, this one has the largest multiplier effect. In this context multiplier effect refers to both economic growth and what might be called "social growth." Put another way, many of the students in the field of public policy feel that federal research and development expenditures are buying our future society. If this be so, then there is a general feeling that we might go about the process of buying our future in a somewhat more rational way.

Given the perception of the problem as it has been characterized in the preceding paragraphs, most students of science and public policy have a somewhat common posture. That posture is that we in the universities live in a particularly acute segment of the analytical society. By breaking up both our natural and social universe into manageable analytical parts we have achieved major breakthroughs in understanding. The adverse

effect of this has been that nowhere in the university do we attempt to take a synthetic or holistic view of what is happening. This would be no cause for concern if the purpose were solely to gain greater understanding for its own sake. It is a very real cause for concern when the purpose is to provide some assistance in dealing with contemporary problems as well as to help plan the kind of future that we are creating.

Most students of science and public policy believe that action cannot wait until full understanding has been attained, and that at least somewhere in the university there ought to be those who have as a time focus the next ten to fifteen years. In particular, the belief is that ". . .we cannot blindly adapt technology to our needs with the traditional assumption that there will be ample time to iron out any bugs on a leisurely shakedown cruise. A bigger effort must be made not only to foresee the bugs, but to forestall their development in the first place."[2] This requires the development of cost-benefit analyses using social as well as economic indicators. In addition it requires a willingness to make qualitative judgements on the basis of the best available even though incomplete data. Most of those in this non-field make the act of faith that we can, over relatively short time periods, improve the level of rationality with which society uses science and technology to achieve desired goals. Most expect progress to be slow and frustrating, but any progress is seen as sufficient justification for work in this area. And the success of work done by RAND and other such organizations with respect to defense policy provides some basis for optimism even though defense is a much more manageable area.

To this point I have emphasized the perception of social problems as the dominant answer to the question: Why science and public policy? There are several other reinforcing

motives for this development in the university. Not the least of these is the continuous search for new intellectual excitement. If the focus on science and technology does provide new opportunities for insight then that is enough to move scholars in this direction regardless of questions of social utility. Further, particularly within political science, there are numerous examples of a movement away from the process orientation that has been dominant in the immediate past. Using a simple systems model it appears that the process orientation has led to a focus on the input and conversion parts of the model. The policy focus tends to emphasize the output and feedback parts of the model. Therefore science and public policy provides a convenient focus of attention for those people who find their previous directions less than satisfactory.

At a time when interdisciplinary research seems to require at least the verbal obeisance of almost everyone, science and public policy also provides a convenient area around which to organize such activity. Someone in nearly every discipline on the campus finds the disciplinary constraints less than satisfactory. This is particularly the case with those in the social sciences who wish to tap the assets of the natural sciences or engineering or vice versa. Again science and public policy provides a convenient commonality of focus.

In attempting to discuss the reasons for the development of a program in science and public policy it would be a serious error not to mention the role of student pressure. Most if not all colleges and universities are feeling increasing pressure from students for something which is usually labeled "relevance." This seems to be related to the notion earlier described as the "analytical university." There is some basis for arguing that we

provide the student with a set of separate and distinct in-depth analyses in our courses. We then apparently believe that through some mystical act this is at some point integrated into the whole man. In fact, of course, we know this does not happen. To the extent that many of the courses in science and public policy are efforts at synthesis they offer some response to the student demands for relevance.

Finally, the development of programs in science and public policy are a partial response to the changing nature of government expenditure for research and development. I shall spend some time discussing government funding, not because it is a more important force, but rather because it is the most concrete of the forces pushing for work in science and public policy.

The crux of our interest are those goals relevant to the expenditure of the government's $17 billion of research and development money. It is the policy which directs the use of these funds that is commonly referred to as "science policy." The activities paid for by this money are widely felt to be a major contributor to the solution of many of our problems. The initial concern here is with the reasons why Congress has appropriated that money and with the changing direction of these reasons. At the most general level, it is perhaps appropriate to talk about the motivations that have led to spending $17 billion on research and development.

Ralph Lapp correctly pinpointed the importance of military security when he said that the program of federal support for research and development was the result of three foreigners: Hitler, Stalin, and Khrushchev. Although military security is likely to

continue to consume the largest portion of federal research and development funds, Congressional and public concern with it are in relative decline. This is so, in part, because the program has demonstrated its success and because it is now well developed. It is also true because our domestic problems are demanding more attention.

Two motives of growing importance in the making of national science policy are special interests and economic and social progress. Special interests include such demands as that for wider geographic allocation of research and development funds and the demands that already existing programs be supported, e.g., the aerospace industry. The special interest motive would appear strong enough to sustain the major elements of the existing research and development support system.

The motive that appears to demand new directions in research and development programs is economic and social progress. This results from a widely held belief that science and technology--included here are the social sciences--can contribute significantly to domestic progress. A second and supportive factor is the belief that, based upon a resolution of the Vietnam conflict, there will be new monies available.[3] Before the Vietnam conflict is resolved, money for major new efforts in the civilian sector will be in short supply. With that resolution most Congressional projections see military-space expenditures remaining on a plateau while expenditures in the civilian sector rise steeply.

With the rising importance of the goal of economic and social progress has come an increasing demand for help from the universities in planning public policy by those Congressional committees which have looked at the technological society. If it can be

said that we have had a public policy for science up to now, then it has only been the sum of all of the individual and discrete decisions made by the numerous federal agencies. There is a growing interest in changing this. No one wants a centralized, monolithic policy-formulating process. Congressmen generally feel it to be the genius of our system that "federal policy determination is fragmented, practical rather than theoretical, and that few formal statements of policy are produced."[4] Nonetheless, there is growing sentiment that improved forecasting and planning of public policy is necessary. The pattern is increasingly to view science and technology as instrumental both to planning policy and to carrying it out. It is thought that wise use of science and technology can go a long way in reducing the costs implicit in a rapidly changing society.

In a perfectly rational society policy would be made something like this: goals would be articulated; various strategies for achieving those goals would then be defined; a cost-benefit analysis of the various strategies would follow. And the final step would require taking action along the lines of the selected strategy.

Although for the Congressman there is an almost humorous air about the rigid order of that process, what we have today seems too far at the opposite extreme. It involves making policy by adding immediate and discrete actions. The emerging theme of Congress is that we must be capable of some pragmatic middle ground of policy making. At a minimum, it is believed that public policy can be so planned and organized that ". . . objectives or goals at subordinate organizational levels should not conflict with those of their parent organizations."[5] In the realistic sphere of politics Congressmen see a policy as being "a rule which tends to answer questions of action in the affirmative or

the negative. Hence, policies set the constraints within which activities to achieve goals must take place."[6]

Congress and the federal government generally are calling for two kinds of policy help from the universities. The simple and straight forward call asks such questions as: How do we achieve better health or eliminate poverty? The other is related but somewhat different: How do we formulate policies, which, while achieving their goals, do not create even more serious problems than the ones they have just solved? That is, how do we anticipate the problems discussed in Rachel Carson's Silent Spring?

Whether systems theory is a response to compelling circumstances or the circumstances are recognized because of systems theory, there is a widely held belief that science and technology have made our society into a highly complex system. Perhaps the politician more than the rest of us has always appreciated that actions in one area have profound effects on highly disparate areas. What Congressmen see as being one of the major consequences of science and technology to date is a changing of the time scale. While in the past it was recognized that individual governmental actions might have wide-ranging ramifications, there was sufficient time to take compensating action for those that were negative. With the collapse of time that the new technology has brought about, it now seems necessary to anticipate what adverse consequences will result from various policy options.

With the recognition of this interrelated and accelerating system the federal government is making increased demands on the universities. Many believe that since the universities have helped society meet problems in the past, they are the logical

places to find the answers to these new problems. Further, there is a negative impetus. Even those who express less confidence in a university do not know where else to go. This is not to imply that there is no role for other institutions, such as the not-for-profit or the profit-making concerns, but rather that all resources will be needed and that the universities are especially critical.

This hope placed in the universities is reinforced by a belief that the methodology is available. It is that methodology which is loosely labeled "systems analysis." This is a belief that the techniques that the RAND Corporation applied to Air Force problems and that were later applied to the Department of Defense can be applied to broader public policy problems. For instance, the Clark Subcommittee stated: "The Subcommittee finds the systems approach to be a promising way to meet and solve some of the complex social and economic problems confronting state and local government."[7]

It is also accurate to say the approach of Congress and the federal government to the university is schizoid. While Congressmen believe that the universities have the intellectual resources, they wonder if the universities can organize themselves to respond. One problem is the tradition of autonomy "where the university has admitted only reluctantly in the past that other universities also exist--and then, let us face it, mainly for the purpose of arranging football schedules. . . ."[8] Secondly, there is the problem of the "walls of separation" between disciplines. It is in response to this last problem that there are continuing calls for ". . . the training of middle-men capable of communicating the results of research to practitioners and the problems of practical decision to social scientists. . .The need for such aids in the process of utilizing research findings and

converting abstract ideas into practical policies is affirmed repeatedly throughout these volumes."[9]

It is not news to anyone who has spent time in Washington in recent years that Washington is convinced of the value of inter-disciplinary, trans-disciplinary, multi-disciplinary, or cross-disciplinary work, whichever term happens to be in vogue. This would appear to be, in part, a reaction of the frustration felt in dealing with the universities and their disciplinary structure. Perhaps no rule is more widespread in the university today than that which says: "When applying for federal support, make it inter-disciplinary." Leland Haworth articulates the ultimate of that view: "It seems to me that the integration of knowledge gained from the social sciences. . .must be integrated with the knowledge of the harder sciences. . .and so an important part of our future thinking is to try to bring this about. . . ."[10]

In summary, then, the hearings and reports of Congress convey the clear word: The government needs public policy help; the universities have the creative talent to give it; systems analysis provides the method, and at present the universities are inadequately organized to offer the help.

It is in response to this feeling--one should perhaps characterize it as a sense--that federal agencies and the Congress are grasping for new organizational approaches. Again Haworth articulates the thinking: ". . .We believe that there need to be some additional centers for advanced specialized research for attacking some of these multi-disciplinary problems, centers for such things as the study of urban ecology, regional planning, economic analysis, things of that sort. This does not mean necessarily that

one sets up a new institution, although in some instances this may be called for, but rather that the resources of the university or several academic institutions be brought together from a broad range viewpoint and have an integrated attack on some of the problems."[11]

It is in response to all of the pressures discussed that programs in science and public policy are growing and in my opinion should grow.

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UNIVERSITY PROGRAMS IN SCIENCE AND PUBLIC POLICY

By Eugene B. Skolnikoff

Early in 1967 a group associated with the AAAS* decided it was time to bring together as many as possible of those in universities and government actively involved in developing teaching and research programs in what can loosely be called "science and public policy studies." It was decided that a series of symposia should be held at the annual meeting of the Association in New York in December, and I took responsibility for making the detailed plans.

The results of these sessions will be reported briefly at the end of this article, but first the results of one of the steps we took in preparation for the meetings must be given. In the spring of 1967 we distributed a questionnaire to all of the universities we could locate that had taken positive steps to initiate teaching and/or research programs in science and public policy, or appeared to be about to do so. The questionnaire was designed to elicit information on their focus, pattern or organization within the university, number of faculty, student body, and other related questions.

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Our objective was first to get a feeling for what was going on in the field, and second, to see if there was a favored pattern or organization that might be of interest and use to others. We met the first objective fairly well, but the hunt for strong trends either in organization or in focus in fact showed a great variety with little pattern emerging. In part, the difficulty was one of differences in definition of the field--of which more later--or of differences in self-image about what each university was doing. Still, the results were informative.

Some thirty universities were polled--we have now identified over forty and quite a few others are interested--and twenty-five usable questionnaires were returned. Of those twenty-five, eight had programs of teaching and research in science and public policy that were organized as separate identifiable programs, as contrasted with simply offering courses. These eight were Harvard, Massachusetts Institute of Technology, Indiana, Columbia, Case-Western Reserve, Purdue, the University of Wisconsin, and the University of California at Riverside. Three others were on the verge of starting such programs: California Institute of Technology, the University of Denver, and the University of Virginia. Five universities offered graduate courses only as part of related curricula, but not as a separate program. Six others offered undergraduate courses only, and the remaining three had considerable faculty interest, but without specific courses or programs as yet. Quite clearly, this last category of "interested faculty" could be expanded enormously if we simply contacted more universities.

The first category of universities with identifiable separate science and public policy programs is in some ways the most interesting for us here. Five of the eight are graduate level programs only: the other three are at both graduate and undergraduate levels. At all

eight a student can specialize in the field for a degree--either M.A. or Ph.D.--though for some the dissertation subject constitutes the "specialization."

In five of the eight, the program is centered primarily in the government or political science department; the other three reflecting a broader university involvement. However, in all cases courses are normally open to the entire university. The numbers of student majors in the field vary from a high of fifteen at Indiana, to two at California at Riverside, (no response from Wisconsin). In 1967, Harvard had ten majors; Columbia twelve; Massachusetts Institute of Technology six; Case Western Reserve seven, and Purdue seven.

It was interesting that in six of these eight, typical class enrollments would have one-fourth to one-half of the students from outside the department in which the program was centered. Moreover, the undergraduate specialties of those enrolled in Ph.D. programs in seven of these eight--again no response from Wisconsin--varied from mostly natural scientists at Purdue to all social scientists at Riverside, with three reporting roughly equal splits among natural sciences, social sciences, and the humanities.

The primary themes of the teaching programs of these eight varied enormously, but six of the eight included policy-making for science and technology as a primary theme. Others mentioned frequently were international affairs, impact of science and technology on society, and public administration.

Four of the eight--Harvard, Columbia, Indiana and Wisconsin--reported a separate identifiable research program in science and public policy that constituted more than simply teaching-related or dissertation research, this being clearly a matter of definition.

Three of these were organized as research programs on a university-wide basis; only Indiana's organization was entirely within the Department of Government. Harvard and Columbia had established separate institutes or programs with independent status within the university. One university--George Washington--which did not send in a questionnaire, also has extra-departmental organization for its research program and others are moving that way, for example, M.I.T. The State University of New York at Albany just established such a center in the spring of 1968. The total number for which information is available is too small to discuss research focus with any usefulness.

The five universities offering graduate courses, but without separate identifiable programs, are New York University, Vanderbilt, Princeton, Yale, and the University of California at Berkeley. In the case of all but Princeton, students can write dissertations in the area as well, so that in practice these programs shade into the eight of the first category. Still, in 1967 at least, these universities did not consider that they had an organized science and public policy program. As noted before, the difference may be more one of self-image than of real substance, or of formal versus informal organization.

Those with undergraduate courses only were the University of California at Davis, Duke, Dartmouth, Florida State, the University of Wisconsin at Milwaukee, and the New School for Social Research.

The questionnaires also asked for other information related to professional matters of interest to those working in the field. For example, responses were solicited on whether a professional organization of some kind was needed. Ten responded yes; fourteen no.

In response to a question as to which organizations were looked to for communication

with colleagues or to report research results, the following were mentioned most often: informal communications, fourteen; AAAS, twelve; APSA, six; ASPA, four; ASA, three, and OECD, two.

When asked if a new journal was needed, fourteen responded no, five yes, and the remainder "don't know," (one no response). However, it was quite clear which existing journals were indispensable: Science was mentioned twenty-one times; Minerva, fourteen; Bulletin of the Atomic Scientists, twelve, and Scientific American, the American Political Science Review, Science and Citizen, and the Public Administration Review, each three times. All the rest were mentioned one or two times. When asked in which journal respondents would prefer to report their work, twelve mentioned Science, four the Bulletin of the Atomic Scientists, and all the rest were mentioned by one or two respondents.

Eleven reported financial support for research was not "adequate," but eight said it was "adequate." The rest did not respond or did not know. When asked if more communications channels among practitioners in the field were needed, an overwhelming number, eighteen, said yes.

Finally, in response to a question about what problems ought to be discussed at the December, 1967 meetings, those most frequently mentioned appear in the table below:

Problems of Communication among Relevant Disciplines	11
Curricula Development	9
Setting Research Priorities for the Field	7
Research Methodology	7
Setting Boundaries	6
Relations with Government	5
Defining the Field and Its Evolution	3

As noted earlier, these results are interesting, but are hard to categorize in a useful

way. The sample is small and problems of definition are critical. Perhaps the most important problem of definition is also an important substantive one: Is science and public policy a "field", a discipline, or simply a grouping of research areas? This paper is not the place to settle that point, but it is a critical question when attempting to elicit comparative information. Where are the boundaries of this "field"? Should the history of science be included? What of the sociology of science? What of programs in defense studies or in urban affairs?

There is no answer to these questions, and in my view an attempt to set boundaries is a mistake, at least at this time. Rather, I tend to consider science and public policy as an "area", much in parallel with geographical area studies found in many universities. This has the virtue of preserving the need for those concentrating in the area to maintain their own disciplinary focus, while also recognizing the need of working with others with other disciplinary approaches and methodologies. This is an arguable position and one that needs more extensive treatment in another place.

Let me close by reporting briefly the results of the December meetings and the projected follow-up. Several traditional symposia were scheduled in subjects related to science and public policy during the regular AAAS sessions. In addition, an invitation dinner and, most important, an unstructured workshop session were held to provide an opportunity for unfettered discussion among the fifty or sixty scholars in science and public policy who came to New York. These informal sessions, in particular, were quite successful and provided an opportunity for the airing of problems, views, and suggestions.

There was a clear consensus by the end of the workshop session that some form of

organizational framework was needed to enhance communication among those in the field. As chairman of the session I was instructed to form a working group and to proceed to develop ideas. The group has come up with a proposal for an interim organization, small in size--as small as humanly possible--attached to M.I.T., that will gain experience over the next two years in what is needed. After that time the situation is to be reexamined to determine what kind of permanent organization, if any, would be useful.

The functions of what amounts to a small secretariat would include:

1. Providing a national focus for exchange of information for receiving and acting on ideas for seminars or specific programs and for maintaining contact with university programs. In short, providing a mailing address and secretariat to facilitate contacts among those interested in developing science and public policy university programs.
2. Arranging seminars, meetings and conferences as appropriate. The assumption is that annual meetings in conjunction with the AAAS meeting will be arranged to continue the pattern set last December to encourage the gathering together of a large proportion of those engaged in university programs. In addition, special meetings with more limited attendance might be set up from time-to-time on specific subjects of interest. Many suggestions of subjects for such meetings were made at the December workshop, and it is clear that there is a need for such sessions devoted to the interests of those in the field.
3. Making provision for easier access to bibliographic resources and for distribution of relevant information pertaining to source material. The availability of relevant

bibliographic material is a problem in this area as in many others, but it can be most serious for those universities without easy access to, or knowledge of, government materials. Over time a small secretariat concerned with this problem may be able to render real assistance through provision of timely bibliographic information. One likely step, as an example, is to make it possible for those universities with unusual library resources in science and public policy, such as Harvard and Columbia, to arrange for their accession lists and card catalogues to be make available to interested parties. In addition, the secretariat could facilitate the informal exchange of reprints, student papers, and other materials as appropriate. It is not envisaged that the Conference will undertake the reprinting or distribution of any papers on its own except in connection with Conference-sponsored meetings.

4. Maintaining an address list of interested scholars, government officials and others interested in the development of the field.

5. Promoting the exchange of information relevant to the development of university programs in science and public policy and to the design of course curricula. Considerable sentiment was expressed at the December 1967, meetings for the value of exchanging ideas and experience on the establishment of new university programs in science and public policy, on the problems encountered in obtaining endorsement and participation of the relevant disciplines, and on the design of curricula. It may be advisable to hold one or more meetings on this subject, but the exchange of written materials may also be useful.

6. Providing information on government and private programs pertinent to the field, such as, research funds and fellowship and training programs. Once again it was clear at the December meetings that many individuals were not aware of the availability of research funds for themselves or their graduate students, nor aware of fellowship programs or the many special training programs of interest within the government. It may be useful from the government point of view to hold one or more meetings with scholars and teachers in the field to discuss the objectives and planning for these government programs.

7. Facilitating the distribution of information pertaining to employment possibilities for graduates in the field. Some kind of matching of opportunities with available graduates in science and public policy may prove to be quite useful.

8. Publishing a newsletter or other information bulletin. As a communications medium, it may be quite useful to distribute some form of newsletter with information on forthcoming Congressional or Executive studies, special developments of interest, personnel changes, information on pertinent meetings of professional societies, and similar information. Such a newsletter would probably not be started immediately, but would be experimented with over the period of the grant to determine its usefulness.

The organization would have a steering committee and is tentatively called "A Conference for Science and Public Policy Studies." It will come into being as soon as some funds can be raised.

One thing is clear through all this: the interest in developing a solid base of science and public policy research and teaching is growing rapidly throughout the country in the universities and the government. The 1967 survey I reported on here is well out of date less than a year later; it will be interesting to repeat such a survey in 1968 or 1969.

COLLABORATION AMONG SPECIALISTS: SOME PROBLEMS AND POSSIBILITIES

By Claire Nader

A major contemporary problem is to understand the social role of science and technology--what it has been, what it is today, and what it can be so that the results serve man's needs and aspirations. This is especially important since different interests of greatly varying power compete in decision-making processes and produce consequences of varying costs and benefits. The choices we make regarding the development and use of science are matters of basic importance, affecting as they do the public welfare now and in the future. The central question is one of controlling or being controlled by the dynamic forces released by the production and application of knowledge. The problem, then, is no less than to weave a unified understanding of the whole process by which science and technology are developed and then applied in a social environment, and of the consequent outcomes.

The compelling need to understand the impacts of science and technology on society dictates a prime role for universities. More conscious, responsible and motivated efforts to develop the requisite knowledge need to be made by the academic community within institutional frameworks which sustain such undertakings. Lodged in the title of this seminar are significant intellectual and practical problems for teachers, researchers, and administrators in institutions of higher learning. We need to be clear about these in designing programs of teaching and research concerning the interactions of science, technology and public policy.

One of these problems is highlighted by the multi-disciplinary characteristic of the study of the social impacts of science and technology. Although the extent and kind of collaboration required among the disciplines are defined by the particular problem under study, there is little question that lines of communication need to be kept open if the problems resulting from scientific advances and uneven patterns of applications are to be understood in anything like their proper shape and distinctive qualities. The cooperation of specialists is vital for, in the final analysis, such individuals will determine the form, substance, and quality of university programs in public policy for science and technology. Thus, it is important to recognice and overcome obstacles which deter productive collaboration.

Some of these can be easily recognized. The difficulty is to face up to them, an especially hard thing to do when "facing up to them" means, in great part, the enlargement of the professional perspectives of highly specialized persons who have devoted many years qualifying as specialists in some particular aspect of a discipline, not even in an entire discipline. Exposure to inter-disciplinary activities in this area of inquiry has impressed upon me that substantive collaborative enterprises will not be easy to establish for a number of reasons. The planning and conduct of two conferences, each of which convened twenty-five to thirty persons trained in the physical, biological and social sciences, engineering, the humanities, and the law to consider aspects of modern science and technology's relationship to human welfare, gave some indication of these. One—the conference on "Science and Contemporary Social Problems"--was held for a month in the summer of 1964 in Oak Ridge, Tennessee; the other--a conference on "Science and

Technology in Developing Countries" was held for one week, late in 1967 at the American University of Beirut in Lebanon. These experiences and others point to some of the difficulties in communication between the disciplines which must be considered in developing programs of research and teaching.

One difficulty hindering collaborative efforts, especially between social and natural scientists, arises from specialized perspectives. The trouble is that we are well trained and badly educated. We have recognized this pitfall for some time now and readily point to articulate spokesmen on the subject of the dangers of specialism. Over forty years ago Alfred North Whitehead in his Science and the Modern World (1925) cautioned us about "a celibacy of the intellect which is divorced from the concrete contemplation of the complete facts." He warned against "the restraint of serious thought within a groove [wherein] the reminder of life is treated superficially, with the imperfect categories of thought derived from one profession." Over twenty years ago José Ortega y Gassett echoed similar ideas in his Mission of the University (1944), and more recently Eric Ashby in his Technology and the Academics: An Essay on Universities and the Scientific Revolution (1959).

Although these discussions were thoughtful and persuasive, we have not effectively heeded them. Narrow professional perspectives still impede the development of associative capacities and an instinct for relevance along the continuum of mean and purpose. Yet public policy problems do not respect the arbitrary divisions of knowledge which we have created, and therein lies our dilemma.

Our high level of specialization has placed us in the peculiar position of having conquered more horizons than we can command. Abundant evidence of this is the many kinds

of environmental crises which we now face and for which new kinds and combinations of knowledge are needed. In effect, we have enlarged our areas of choice faster than we have improved our ability to make "intelligent" choices. Moreover, we have created an imbalance in the kinds of horizons we have pushed back.

Embedded in this situation is an educational problem. We usually teach a specialty so that progress is made within "its own groove of abstractions," as Whitehead put it, to the detriment of abstractions which are adequate for understanding the complexities of modern life. Unfortunately, specialization has given impetus to parochial habits and attitudes and has significantly reduced the common fund of experience among specialists. However, such habits and attitudes do not necessarily have to result from specialization. Much depends on how a specialty is taught. Toward this end we must not assume that the educational problem in the universities can be met by a good dose of liberal arts subjects. Present-day training in non-technical subjects may be as highly specialized as anything found in the technical subjects. It is not a matter of a confrontation between specialization and a liberal education, for they are part of the same necessary fabric.

How, then, do we educate in the technical, social and humanistic studies, all of which have their own brand of narrowness, so that the result is a liberally educated person? I suggest that we make the various specialties the basis for a liberal education, emphasizing the relevant organizing ideas along with the techniques to be mastered. The source of stability here is a sound grounding in a subject area, and the source of innovation and invention is some understanding of how that subject matter relates to human purposes.

Let me try to illustrate. In a course in automotive engineering a discussion of the

priority to be given safety design along with factors of cost and markets would help etch more clearly the problems of competing values, and how they are, and should be resolved, to promote the dignity of man in his pursuit of happiness. In this manner an engineer will have to face the profound human implications in such concepts as "up to a certain point the country has made a decision to tolerate accidents." As a matter of historical fact, this country permitted a decision for an awesome toll on life as the alleged price for constructing a railway system. As long as brakemen cost less than the technology to eliminate the surrounding risks, railroad operations consumed brakemen until a number of insistent engineers found a way to inject airbrakes and the automatic coupler after years of urging that attention be paid to the detrimental effects of railway technology.

The terms and validity of this type of decision are as much within the province of engineering as they are within the province of the humanities and social sciences. The introduction of the "human factor" into engineering instruction itself is a much more effective way to stress its importance than the one-fourth humanities requirement in engineering curricula. It might even deepen the student's appreciation of this requirement, better enabling him to perceive its relation to his "major."

Once the budding engineering student is trained to examine the technical and human aspects of his specialty, he begins to think of <u>this</u> mix of factors as an intrinsic part of his professional knowledge and responsibility. Proper training should articulate the scope of his responsibility and provide an engineer with standards for professional conduct in actual practice. It should help him appraise a problem comprehensively and recognize that technological developments can force, as well as enable, ethical decisions. Thus, even though

his expertise is limited to only a part of a problem, he becomes sensitized to the additional kind of knowledge needed to anwser basic questions.

The education of students and the self-education of specialists must be concerned with the various ways that different modes of intellectual activity can be interlaced for a fuller examination of a problem and tested for contextual appropriateness. The Oak Ridge conference moved in the direction of effective interdisciplinary communication. Indeed, it was distinctive more for the kind of discourse conducted than for providing solutions to problems. In any case, solutions mean nothing unless a problem is defined organically with the necessary specialized knowledge brought to bear on it.

In addition to narrow professional training, the so-called information explosion in each field of learning has reduced the common fund of knowledge and experience among specialists, rendering the process of communication more difficult. Even with the best of intentions to communicate, it is not easy for specialists to shed professional perspectives and seek the knowledge necessary for study of public policy for science and technology. For one thing, it is far easier to talk about that which one knows best. For another, it takes much intellectual and emotional energy and a healthy amount of commitment to undertake serious discourse with persons trained in other disciplines than one's own. This is particularly so between social and technical scientists. At the Oak Ridge conference awareness and interest in the process of communication itself existed. An appreciation developed that no one viewpoint can alone define contemporary problems adequately, and that past modes of definition need to be reconsidered. Apparently this appreciation has to be acquired; it cannot be taken for granted among trained individuals. Indeed, the executive director of

Harvard's Program of Technology and Society reported as one of the Program's first-year achievements the increasing ability of faculty members from different disciplines--who had met in seminar during the academic year--to communicate substantively with each other.

At Beirut what mattered was not so much the specialty represented by each conferee, but whether or not the viewpoint expressed and the supporting data were helpful to an understanding of the problems and possibilities of developing and applying science and technology to national goals. This concentration was due in part to the fact that enough of the participants were broadly based specialists, and in part to the urgency and importance of developing-country problems. The sheer magnitude of these problems eschewed parochial claims to omniscience. In fact, my present remarks about difficulties in communication are really limited to the U.S. academic community. Specialists in developing countries are not yet so highly insulated from the social events surrounding them. There are not so many of them; nor is the level of specialization as compartmentalized as in the more technologically advanced nations.

Experiments in inter-disciplinary communication are risky, for the organization of complexity is not generally practiced by specialists. Yet, using a particular discipline as a point of departure for organizing complex phenomena, that which cannot all be understood by one field of knowledge, can yield surprisingly effective results, both by strengthening the discipline itself and by making a positive social contribution.

This orientation is hard to come by. The narrow professional perspectives of specialists are fortified by a system of rewards and deprivations in universities which in too many

instances make a mockery out of an otherwise perfectly good word--interdisciplinary. For example, if a physical scientist cooperates with a social scientist on research problems requiring the integration of their specialties, he runs the risk of not being considered a physicist any more. He must also do independent research to maintain his position among his colleagues in physics. And, if he takes both sets of research problems seriously, he carries an extremely heavy load. If he is young and still not securely established in his field, excursions from "pure physics" are subject to criticism. I doubt that such criticism is very often made overtly. There are many more effective ways to get the message across.

On the other hand, social scientists embarking on explorations in fields not conventionally viewed as social--or within the social sciences moving among the disciplines seeking new outlooks--will need to experiment to find the best routes for their purposes, both intellectual and practical. Since they will be dealing with unfamiliar subject matter in some cases, they need to be supported and rewarded by their colleagues for venturing into uncharted territories. Unsuccessful ventures must be borne by the profession and viewed as learning devices. Not every experiment conducted in the physical and biological sciences is successful. Much is learned from the failures although these are rarely reported. In short, programs which require interdisciplinary collaboration of one sort or another need to be buttressed with the kind of supporting environments equal to the level and quality of the objective sought.

The reluctance of social scientists to plunge into the technical knowledge bin for information required to formulate the problems, deters work in this area of inquiry. A feeling seems to prevail that this information is alien and beyond them. What is needed, in fact, is some hard work to master new information and technique and to become comfortable with the technical data in cooperation

with specialists who are privy to this knowledge. Without regular interaction with physical and biological scientists and engineers on one's own campus, it is likely that problems stemming from the work of these persons will not be identified systematically by the student of science policy.

Social scientists must have sensing devices in scientific and technological work areas if commitments to the study of public policy for science and technology are to be taken seriously. Steady communication on the campus itself will increase the social scientist's skill in extending his sensors beyond the campus. If his interaction with the technical world is limited to infrequent and sporadic excursions to laboratories and installations outside of the university, the technical material with which he has to deal will not become an integral part of his milieu. Regular or continuing involvement with technical and scientific developments is essential for the social scientist who is going to be attuned to the substance and meaning of the interactions of science, technology and public policy.

Excursions to national laboratories and other scientific or technical institutions must supplement ongoing campus interdisciplinary activities. They are not, however, substitutes for campus involvement, and may even be detrimental if the scientific activities which occur at Oak Ridge, for example, are seen as different from those which occur in the universities. In discussion with social scientists who have participated in Oak Ridge conferences--designed essentially to acquaint them with such sciences as nuclear physics or molecular biology, so that they, in turn, can consider the policy implications—I have always had enthusiastic reactions from them to this experience. When asked to be more specific about their gain, one social scientist at the associate professor level put it this

way: "Before I came here, science was something way over the horizon. Now I know more about it." Apparently he saw a difference between Oak Ridge scientists trying to understand physical and biological phenomena and his own efforts to understand social phenomena. He did not fully understand that both were attempts at discovery, and that what was new and different to him was the subject matter, not the process. The impressive verification techniques which the physical sciences have developed sometimes cloud the point that all scientists are engaged in the process of discovery, even though the process of verification will be shaped by the phenomena being analyzed, and therefore might differ from one discipline to another. Thus, physical scientists tend to be separated from the community of scholars with which social scientists interact on a regular basis. Collaboration is made difficult enough by different subject matter without adding barriers resulting from erroneous images of technical specialists as individuals somehow alien from specialists in social phenomena, merely because methodologies differ.

Finally, even if we were well trained and well educated, communication between the disciplines would be made difficult by the sheer quantity of knowledge in each field, as noted earlier. The more one knows about a specialty, the easier it will be to communicate with specialists in that field. Here, however, we have to let the problem determine how much we need to know about its technical aspects. Nonetheless, a social scientist whose problems have significant scientific or technological components will have to absorb quite a bit of technical information to become skilled in selecting what is pertinent. The more he works in such problem areas, the more he will find himself at ease in searching for the relevant information in the technical literature, thus gaining general familiarity with the

substance of the technical areas.

Clearly, the drive for conceptual integration will not be without its frustrations and failures. It took a long time to arrive at today's high level of specialization. The resulting excessive compartmentalization of our thinking will not be overcome quickly. Conceptual integration will require special, long-term care.

A significant first step in seeing how different modes of intellectual activity can be effectively coordinated in research and teaching is a willingness to listen sympathetically to persons trained in disciplines different from one's own. The Oak Ridge conference took this first step. Plenary conferences are reasonable and sometimes necessary initial efforts toward loosening the intellectual apparatus of narrowly based specialists. At both the Oak Ridge and Beirut conferences there was an expressed desire to go into greater detail. It is important to follow up as soon as possible with frequent, smaller working sessions where one can develop the data needed to define certain problems (including problems of communication) and begin to discover what it is we want to integrate, for what purpose, and how.

It is important that the kinds of exchanges of ideas and experiences stimulated by conferences occur, as a rule, with some of the same individuals present each time. In terms of physical proximity this can easily happen on a university campus. A leisurely approach to interdisciplinary communication is to converse daily on a university campus with colleagues from different disciplines so that some understanding is developed of the subject matter which comprises a discipline, the questions it asks, and the techniques it develops to answer them. Understanding and respecting the language, perspectives, and

substance of disciplines other than one's own is a precondition for collaborative efforts by specialists. This is especially true for those who do not come to interdisciplinary communication via a problem that already involves them and for which they already recognize the importance of contributions from other fields of knowledge. Having begun communication at this level they may discover specific problems which require inputs from the social and technical sciences for their proper definition. The coalescence of specialists around a problem which involves them professionally provides a congenial setting for discovering useful combinations of specialties and ways these can be made mutually reinforcing.

A "problem orientation" emerges as a catalyst for improved communication between social and technical scientists. Cooperation toward solving problems which concern both social and technical scientists professionally is one of the quickest ways to begin meaningful communication. Such an orientation can better define a problem, provide a pedagogical experience for the specialists involved and, important for continued activities, can lead to social relations--outside of purely professional exchanges--where learning by osmosis can go on. The social scientist, from his viewpoint, can play a dual role of participant-observer, since study of the scientific subculture may be one of his main interests in addition to the particular problem under collaborative analysis. In studying the scientific subculture itself, he has to depend for information on the goodwill of the technical community as he examines its place in society. Technical scientists are not likely to undertake this kind of research.

In any case, in the study of public policy for science and technology the professional responsibility for establishing communication links lies with the social scientists, for the problems that science and technology raise are mainly social problems. Their resolution may

well require the application of physical and biological knowledge. But, unless technical scientists have an extremely strong sense of social responsibility for the use of their findings, they will not usually consider it their professional responsibility to communicate knowledge bearing on national welfare unless prodded to do so. They may not even recognize the public policy implications of their work. Thus, the initiative for communicating with technical specialists fall to the social scientists.

In experiments with interdisciplinary activities it is important to involve persons who want to communicate and who can explain their work to other specialists without having to use the jargon of their particular discipline. There is somehow, something suspect about a person who cannot convey what he is trying to do, or who makes it difficult to grasp what is necessary to understand him. One may ignore his information, but this may be to the detriment of the problem-solving effort.

It is important to lead from points of strength when charting new areas in a particular academic setting. A liberal arts college, a technical institute, a university with professional schools--each may well design different kinds of programs for the study of science and public policy. Faculty seminars need to raise questions of academic objectives in determining the shape ond content of the programs. In outlining their form and substance the faculty itself must become sensitive to the requirements of interdisciplinary efforts on the part of individual professors and on the part of the institution. Both individuals and the institution have responsibilities to create supporting environments.

Simultaneous with faculty seminars that may be convened, I would recommend student seminars with the same mix of specialties (or majors), a similar assignment with regard to

establishing programs, and a fair amount of autonomy. It would be more than interesting to see what they come up with in the way of ideas. Their inhibitions for interdisciplinary activities are likely to be fewer--if you catch them early enough in their education—and the result may be innovative. It is important to design these student seminars carefully and view them, as well as the faculty seminars, field trips, or any other exercise toward achieving programs which are organically related to the academic setting, as experiments in search of more effective modes of learning for teaching and research purposes. Flexibility in testing ideas must be maintained for optimum results. It would be quite a stimulus to other programs if these experiments were reported candidly.

Finally, when a plan of action--that is, a program—is formulated, it is important to make explicit its implications for the established, but perhaps no longer relevant, ways of the university in order to determine its chances for useful work. A system of rewards must correspond in some fashion to the objectives set for the program.

SOME PROBLEMS OF CURRICULUM DEVELOPMENT

By Lynton K. Caldwell

The obvious first problem in curriculum development in a new field of study is delineation of the field. When the field is the interaction of science and technology and public policy, the task of definition is, to say the least, complex. Science and technology have been studied from several disciplinary viewpoints. (References to some of these approaches are appended to this paper). Better known among these viewpoints are those described as (1) the history of science; (2) the philosophy of science; (3) the sociology of science; (4) the political science of science and, (5) simply the science of science. There is potentially, and often in fact, in specific university courses and in the literature a considerable overlap among these viewpoints or approaches. Each of these approaches may also be taken toward the study of technology, but in many instances science-based technology is subsumed in the term "science."

It is less important to identify the outer limits of a new field of study, which are in any case always changing, than accurately to define its core. But the study of science policy, like an onion or perhaps the earth, has a core that may, so to speak, be peeled off in layers. Not everyone may agree, however, as to which are the outer and which the inner layers.

In my view, the innermost or most basic layer in the divisible aspects of science policy is the impact of science and technology on society. In the contemporary world the forces of science and technology, although conceptually separable, are in fact so mutually dependent and synergistic that I prefer to bring them together in the composite expression

"technosicence." This does not rule out separation of science from technology and vice versa where they are in fact separate phenomena. But in modern society they tend to combine to form the syndrome of the universal technoscientific culture that now overlays traditional cultures among the more "advanced" nations of the earth. I believe the impact of scientific concepts and technological innovations on society to be the most fundamental aspect of the policy question, because it is through inquiry at this layer or level that the forces that generate science policy are found.

In our seminar at Indiana University we have begun with a consideration of the meanings of science and technology, their relationship to modern culture, and their impact upon society. Unless there is at least a minimal appreciation of the force and effect of technosicence in the world of today, considerations of public policy for science and technology are likely to lack perspective, depth, or full significance. The cybernetics of technoscientific policy issues is, of course, the essence of this major subdivision of the field of public policy for science and technology. Elaboration and detailed examination of specific aspects of science-policy interaction lie farther out from the very core of technoscientific policy study.

Whether this aspect of an instructional program is properly described as political science, sociology, social psychology, or merely as generalized behavioral science seems unimportant when one considers the totally interdependent relationship of the subject matter of these disciplines to any adequate understanding of the role of science in society and its effect upon government. This cross disciplinary fusion has presented no curriculum problem thus far at Indiana University. It could give rise to difficulties in universities where traditional disciplinary lines are jealously guarded, but in these institutions, if any yet remain, the study of public policy for science and technology would not be likely to flourish.

Between the inner core of social impact and the outer layers of specific aspects of technoscience-public policy interaction lies the area of investigation with which everyone who studies public policy for science and technology is concerned. This is the layer or area where attention is focused upon the ways in which governments deal with science as an institution and a resource. It is the area in which public policy for higher education, for research and development, for international scientific cooperation are considered and in which the effects of technoscience upon politics, law and public administration are explored. Four-fifths of the first semester of the Indiana University seminar cover several aspects of this major area of the field. This is the area of the study that seems most closely related to political science and to the study of public administration. It is the area represented by most university courses in science and public policy and may be considered as providing the common and characteristic subject matter and focus for the field.

Extending and summarizing this comment on delineating the field, several generalizations may be helpful. First, the field is multi-disciplinary, but with certain traditional disciplines assuming a primary role in different phases of the subject. Second, it divides readily into subfields and into topics for which fairly well defined literatures are available and for which separate and specialized treatment is feasible. Third, the inner layers or core subject matter of the field imply an understanding of the nature and significance of science and technology, but they do not require unlimited substantive scientific knowledge. Obviously, knowledge of one or more sciences and of the history of science would be highly beneficial to anyone working in the field. Some knowledge of the substance of science becomes necessary where, as in Topics 16-30 in the Indiana Seminar, the effects and implications of specific technoscientific theories or practices are considered.

The foregoing remarks assume the existence of a field (or, to paraphrase Kash, a "non-discipline" rather than a non-field). Whenever there is a systemic body of phenomena amenable to study, a field for study exists. As Brewster Denny has observed and our bibliographical studies at Indiana have confirmed, there is a large and vigorous literature on science and public policy awaiting organization into an academic field of study. The fields of inquiry have already been identified by writers and researchers. The organization of the bibliography that is being published at Indiana University this year with NSF assistance, and the design of the courses at Indiana, Purdue and at most of the other schools now offering instruction in the field have, in the main, followed the topical groupings indicated by the literature. The organizational problem is not formidable as it might at first seem.

More serious from the viewpoint of instruction and course planning is the level of generalization. This has been a continuing problem in all disciplines and will presumably continue to be so so long as knowledge expands. In a new field the task is especially difficult because there is little by way of evaluated experience to rely upon. Traditional academic respectability usually indicates narrow scope, low level of generality, and elaboration of the subject matter in depth. Although I would certainly be opposed to levels of generalization that were detached from a solid informational base, I nevertheless believe that the very purpose for which public policy for science and technology is studied implies a relatively high level of generality.

The levels of generality indicated by the topics of the Indiana seminar were selected upon the basis of trial, conjecture, and experience in other universities. Among the

considerations relevant to finding the appropriate level of generality is the informational background and comprehension level of the student and the state of the literature. In addition, a very practical consideration is the ability and inclination of the instructor. As to the relative merits of extension in depth or breadth, I would paraphrase a remark of George Sarton by saying the both approaches ". . .are equally inexhaustible; they are equal in infinitude." General knowledge as Sarton noted, is not the same as universal knowledge: "One may know a general field without knowing every detail of it."

In planning the Indiana University seminar we have tried to avoid crystalization at any fixed level of generality. The course is a response to the needs and interests of students. These needs, interests, and the informational backgrounds of students will vary. We have therefore designed a course syllabus that will have maximum adaptability for the individual, will facilitate study on his own initiative, and will permit in-depth study to be carried as far as any student is able to take it. Topical outlines and abstracts provide a detailed and comprehensive overview of the subject matter of the topic. The outlines suggest the range, complexity, and ramifications of the topics, but this does not imply that all sub-topics are to be studied in equal depth or, indeed, in depth at all. Almost every topic in the course could be easily expanded into a full two-to-three semester hour course. The references, keyed to the topical outlines, provide as extensive and thorough a coverage of the topical field as all but the most specialized interests would require. Nevertheless, the level of generality will be a matter for decison in any given course for any specific group of students. The final generalization that I would offer on this problem is that the most productive and defensible basis for decision here is the learning process of

the student. Whatever facilitates student learning, and initiative in learning, would seem to me to be meritorious.

In any new field of study bibliography presents problems. With the current proliferation of publication, sheer volume of material becomes problematic in many fields and public policy for science and technology is one of these. When, three years ago, we began to develop a curriculum at Indiana University, we surmised that the paucity of published materials would be a major handicap. But we soon learned that the reverse was true and that there was a very large literature in existence that had not been identified. The reference base for our seminar consists of approximately 3,000 articles and books and we continually find materials that should be added. We have recently published the first volume of a bibliography of science, technology, and public policy with the assistance of the National Science Foundation. This 500 page volume lists and annotates books, monographs, and government documents. For the second volume we already have brought together twice as much additional material from an already selective list of journals. The bibliography, plus a new bibliographical service by the Battelle Institute and numerous specialized bibliographies now available, should greatly ease the problem of the selection of readings for the designer of new courses in the field.

Two different kinds of bibliographical problems, however, emerge from the nature of the literature. First, it contains few, if any, general systematic works resembling textbooks. Collected essays and symposia are numerous, and in major subfields there are comprehensive studies that could provide basic reading for courses in, for example, the history of American science policy. General systematic works will probably appear in response to a developing

clientele. A second problem, for which the solution is less obvious, is that of rapid change in the literature. This circumstance is also characteristic of all fields of study today and especially in the sciences. The pertinence and vitality of a course in science policy are greatly increased by use of contemporary materials, and this requires use of the journals, Congressional committee prints, and other government documents, and frequent and sometimes legally questionable use of Xerox copiers.

The use of contemporaneous material does pose problems of cost and time. The periodical literature is distributed over a much wider range of journals than is characteristic of the established disciplines. Our bibliographical work has indicated that there are at least fifty journals that regularly and frequently publish pertinent material. Unlike the disciplines of economics, physics or engineering, there are presently no journals exclusively devoted to the subject matter of the field. Possibilities for such a journal are currently being considered. but the nature of the field itself suggests that a wide dispersal of published writings may always be expected. The investment of materials search-time by the instructor may therefore be expected to be greater than in most other fields.

Extensive use of periodical material implies costs of replication. Copyright requirements also complicate the use of journals, as some reproduction of articles is usually necessary. These problems remain to be coped with as no immediate convenient solution appears likely. Money for materials replication should, however, be provided in the budget for any new course or program in science, technology, and public policy.

A final problem of curriculum development is the preparation of the instructor himself, the first generation of scholars in this field has been largely self-developed. They have

emerged from diverse academic backgrounds, often building on successful careers in other fields of scholarship or of public service, Harrison Brown, Don K. Price, and Eugene Rabinowitch may be cited as cases in point. We are now beginning to receive the first products of a second generation of scholars who have received at least some formal training in the universities that have pioneered in this field. It seems probable, however, that there will continue to be a horizontal movement of scholars into this field across disciplinary lines. The natural sciences from the outset of this development have been a major source for leadership in what is essentially a social science, although multi-disciplinary, field. I believe that the continuation of this cross-disciplinary flow is indispensible to the vitality of the field and should be encouraged.

We need to create suitable opportunities for post-doctoral reconversion of scholars who bring competence in particular sciences into the science policy field. Existing post-doctoral programs are generally intended to deepen the competence of the scientist in his special field of investigation. New types of post-doctoral grants may be needed if scholars trained in the sciences--social as well as natural--are to contribute with full effectiveness to the field of science policy studies.

At Indiana University we have found our entrance into this newly developing field a challenging and exciting experience. Our efforts have been confined to the graduate level of instruction. The study of public policy for science and technology will probably remain primarily a graduate field. In the developmental phase of curriculum-making it is easier and more economical to work with relatively small numbers of relatively mature students. Ultimately, however, some part of the science and public policy curriculum should be made available to undergraduates. But this prospect opens another very large field of discussion. It is related to the very large question of how best to assist undergraduate understanding of science, both in substance and as an influence in the world today. For these matters other discussions at other times and places will be necessary.

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REVIEWING AMERICAN SCIENCE POLICY

By Philip B. Yeager

I am not quite sure that I can say exactly what science policy is. It seems to be one of those phrases that has come into popular usage without any generally agreed upon definition.

In fact, "science policy" reminds me somewhat of the old story of the blind man and the elephant. It depends on which part of it you have touched -- or which part has touched you. In short, there does not appear to be -- and quite possibly there cannot be -- any uniform concept of what science policy is intended to do, let alone what it may be.

Now, having said this much, I will proceed to say what our science policy is, or what I think it is -- if you will overlook the anomaly.

Please keep in mind that I am talking only about the policy of our national government with regard to science and technology -- and then, for the present anyway, only in a domestic sense.

What is the domestic science policy of our government? I view it in very elementary terms as first the continuing development of science and technology at an optimum rate. This development is of major importance to the nation. Why? There are three major reasons.

1. Improved science and its applications can help us solve the severe problems which afflict our society. This includes our national security and has special reference to weapons systems and their deployment and use; it includes our efforts to deal with deteriorating physical

environments, with crime, with urban decay, with automation, with congested traffic, with medical care, with racial unrest, with the economy, with overpopulation, and, perhaps most of all, with understanding the ecology of the planet.

2. Improved science and its support is necessary in order to supply new muscle and intellect for our educational system -- without which the future would, indeed, look bleak. Government has come to depend on the educational institutions of the nation for the bulk of its research needs. Those institutions have similarly come to depend on the government for aid in developing their science facilities and research projects. It is a two-way street and a fact now rather freely acknowledged on both sides.

3. Improved science is valuable for its own sake. It is a significant part of the evolution of human civilization. There was a time, and no so very long ago, when the bulk of our civil servants in any of the three branches of government certainly did not construe science in the pure pursuit of knowledge as a very proper object of the taxpayer's dollar. The scales probably began to tip in the post-World War II era when Americans became aware of the debt they owed to the "pure" science of Europe -- and especially to Enrico Fermi, Niels Bohr, Albert Einstein and Lise Meitner -- an Italian, a Dane, an Austrian and a German. Let there be no mistake -- the real political motive behind even such acts as creation of the National Science Foundation was hope of practical gain of one sort or another. But we in government had at least progressed to the point where we recognized that we had to know the basic tricks if we were to pull any applied rabbits from the scientific hat. Since then, I believe there has developed a much more intellectual and sophisticated view of science by Congress and the Executive chiefs. It is not universal by any means -- but there is now a

large number who recognize the intrinsic value of science not alone for what it provides materially, but for its promise in letting man live in harmony with and understanding of the natural world around him.

The second element of our Federal science policy is -- in view of the foregoing reasons -- to support science and technology wherever and whenever feasible, in the universities, in industry, in the non-profit organizations -- within the government itself.

And so in the past two decades Uncle Sam has evidenced a willingness to put taxpayers' money to uses which would not have been dreamed of, let alone tolerated, three decades ago. Prior to World War II federally sponsored research was aimed almost solely at agriculture and electric power, with a little on the side devoted to aeronautics and certain aspects of transportation and defense. Today a dozen or more federal agencies are putting $17 billion into research and development -- almost ten percent of the federal budget -- ranging all the way from lunar landings to oceanography and from auto exhaust controls to the sex life of the aphid.

In effect, a new meaning has thus been given to the constitutional "science" clause -- one not particularly contemplated by the Constitution's chief protagonists, Madison, Hamilton, and Jay, but one undoubtedly in accord with the thinking of such early technicians as Franklin and Jefferson.

The third element of our federal science policy has been, up to this point anyway, that control of the support for science and technology should not be centralized. No one or two agencies should be responsible for federally sponsored research, nor should the main ones whose chief mission is research, such as NASA, NSF, NIH, AEC, NBS, ESSA, Marine

Resources Council, and Coast and Geodetic Survey, be regrouped and housed under a single roof. The premise has been, and it is still accepted, that federally sponsored science must not be under the thumb of a single super-bureau which might easily prove rigid, biased, or unimaginative in its role as comptroller of all science support.

Fortunately, the government, the academic community, and industry all agree on this--and not only in regard to applied research, which is easily understandable from the vantage point of agency missions, but in regard to basic research as well. The rationale for multiple-source funding of basic research is somewhat more subtle and complex, but it exists nonetheless and also seems accepted up to this time.

Is this really a national science policy? It certainly is not a very complex, structured or detailed policy. It really is not even an enunciated or necessarily a permanent policy. It is mostly an implied modus operandi. And it does not begin to explain how things work with regard to priorities, the relationships between administrator and scientist, the problem of the poor versus the rich university, or of geographical distribution. It does not attempt to describe the scientific estate or the "establishment," so-called--though many are convinced there is such a thing and that it really determines American science policy.

But all of these matters are fuzzy. It is very difficult to pull out any formula or observation which can be stated as a uniform, predictable policy with respect to any one of them.

To take one example--the 200 BEV accelerator proposed for Weston, Illinois. What rationale is behind the priority given to the accelerator? (Not that given to the facility itself.) Who was most responsible? NAS? The Congress? AEC? NSF? OST and FCST?

PSAC? Or was it the remnants of the old World War II Lincoln Labs-Los Alamos axis whose guiding lights are sometimes alleged to have been dominating U.S. science ever since? What logic actually governed the selection of the site? And, in this case, did an "in-group" make the recommendation; and if so, was its real advice followed? These are questions on which we have all read much and speculated much. Certainly, they are questions of policy. Just as certainly, very few know the answers, and I sometimes wonder if anyone knows them all.

But the point here is to suggest that many of the important details of federally assisted scientific endeavor in this country are decided without responsibility to any policy, formal or informal, other than the rather general one here outlined. Whether or not this is a good thing, of course, is open to discussion.

Suppose we speculate a moment on the immediate future of government-sponsored science in this country. We have all heard many predictions, most of them gloomy. Some of this stems from the graduate student-draft problem, some from the gold problem, some from the pressures on federal agencies to get out of basic research, but most of it comes from competition with other needs, military and social, which have become compelling. Everything you have read in the trade press on this score in recent months has been pretty scary, but I am not so sure things are all that black. Let us look at the 1969 federal budget, for example.

National defense accounts for forty-three percent of it, about $80 billion, which alone is about the same as the <u>total</u> federal budget of our heaviest World War II years. Clearly someone is due to get hurt. And they have been. But how has research and development fared?

Six agencies have experienced cuts from the 1968 level: Agriculture, $15 million;

Maritime Administration, $7 million; HEW in health facilities construction, $29 million; AEC, $24 million; NASA, $447 million; NSF in institutional programs, $31million. This totals $553 million. But overall federal research and development is up over 1968 by nearly a billion dollars to $16.6 billion--or over a billion dollar increase to $17.3 billion, depending on how one classifies certain items. Either is an all-time high. The biggest part of the increase, naturally, is in military-sponsored research. Yet it seems significant that, in spite of the squeeze, civil research and development is up nearly $70 million to $6.9 billion--or to $8.4 billion if you count atomic energy research factors which has special significance for both the military and civil.

There are several ways of viewing these figures. One is to note a drop in the annual percentage increase. It is up about four-and-a-half percent from 1968 to 1969. This compares with the Eisenhower years when research and development increased on an annual average of fifeteen percent and the Kennedy years when it increased annually by sixteen-and-a-half percent. The Johnson administration has seen an average increase of about three percent. Some people bemoan this as not doing much more than keeping pace with inflation.

However, I am not willing to read into this a disenchantment with science and technology on the part of the public, as some observers do. The dawn of the Space Age, with tremendous spurts in research and development, and by no means all of it for space, came in the Eisenhower-Kennedy years. And the great military demand for dollars has been almost exclusively within the tenure of President Johnson. Think what you like about Vietnam or our civil disorders and eroding environment--it is hard for me to espouse any special meaning from the fact that they exist simultaneously with a slow-down in science

spending, other than a natural competition for a limited number of dollars. The case for the public's caring less about science may be a good one, but it does not yet seem to have a truly substantial base.

Of more pertinence, perhaps, is a comparison of research and development spending with the controllable part of the budget. The Bureau of the Budget puts national defense in a category by itself. It then lists certain programs as "relatively uncontrollable." These include Social Security, Medicare and similar trusts of $38.5 billion; interest on the public debt of $14 billion; public assistance, $5.7 billion; veterans benefits $5.2 billion; farm price supports, $2.9 billion; to give some examples.

This leaves, out of the overall $186 billion budget, $39.5 billion that is "relatively controllable." If we consider all of the federal commitments to research and development as "controllable" they amount to almost forty-four percent of the controllable part of the budget. If we eliminate military research and development, the civil portion is still twenty-one percent of the controllable part of the budget. This seems to be a pretty high figure, and it can be left to the reader's own assessment whether it signifies a down-grading of science and technology.

On the other hand, there can be little doubt that if our military and social-support programs continue to escalate, competition for funds in the "controllable" part of the budget is bound to get tighter and tighter. Science will have to fight to maintain its relative position in the affections of the federal treasury. I am not competent to make any suggestions about what to do about it. But I shall quote the recommendations of a member of Congress who is an "old pro" and who is by no means antagonistic to the federal support of science and technology.

First, the science community should take greater pains to make clear that its efforts contribute directly and indirectly to progress benefiting every man, woman and child in the country. The public won't buy science for science's sake, so sell it to them for their own sake. The public interest is in the 'human sciences'—man as a living being and man in his environment. That is where it is going to put its money. Adjust your research priorities to the public's priorities to the extent you can. The public does not ask for a money-back guarantee if your idea fails, but it wants reasonable assurance of some visible benefits if it succeeds.

Second, the public should be reminded ceaselessly by scientists of their vital contributions to national security. There is no function more appropriate for the Federal government than to provide for national defense. And there is no other purpose for which taxpayers more willingly approve expenditures, I do not mean that every research pig-in-a-poke stamped 'national security possibility' should be funded. I do mean that where reasonably there is such a possibility you have a responsibility to your profession to make it clearly known.

Third, I respectfully recommend that you stop knocking exclusively on Uncle Sam's door for your research support and start hitting up the rich private foundations for some of their money. They have largely stayed away from grants to the physical scientists. They have done so because the government was supporting them generously. Now that this is no longer a fact, it should be made known to the foundations and their assistance sought.

I simply bring this to your attention for what it is worth, and I do not necessarily suggest it as a method that ought to be followed. It may be offensive to many scientists for a variety of reasons. But I would point out that when one is dealing with money of this magnitude, one cannot help conflicting and competing with those of a pragmatic—and usually persuasive--turn of mind. Maybe, in the final analysis, it all depends on whether, in the mind of the scientist, the game is worth the candle; is worth the effort to develop real public understanding of the value of science to society.

If it is any comfort, the scientist might keep in mind that Uncle Sam is now pretty well convinced that research and development is a way of life. He has to have it in order to help solve the enormous problems which confront him. And, as Vice President Humphrey recently observed, in one way or another Uncle Sam is going to get the information and expertise that public necessities require.

Meanwhile, a considerable ferment is going on within Congress itself which may result in new facets of public policy which could conceivably crystallize into part of our science policy. Half a dozen committees of both House and Senate are so engaged, mostly in connection with specific problems, however, such as the brain drain, research versus teaching, social science support, pollution and the environmental effects of nuclear energy.

The most broad gauge activity of which I am aware, however, is that of the House of Representatives Committee on Science and Astronautics in connection with Technology Assessment. We are making strong efforts to develop new methods of assessing technology and particularly a capability withing the Congress to gauge correctly where we should place our support for applied science. Toward this end Congressman Daddario has introduced exploratory legislation for the creation of a Technology Assessment Board within the Legislative branch. We have held seminars with the social scientists on the subject; we are pursuing individual technology assessment problems through hearings; and we are contracting with both the Academy of Sciences and the Academy of Engineering for specialized studies of technology assessment techniques.

The kind of assessment spoken of would cover all types of technological policies and problem For example, what do we do with federal laboratories which are on the verge of

completing their missions? Are institutional grants the answer to creating more "centers of scientific excellence?" Can we avoid the possible disaster facing us through biological disintegration by promoting a theoretical ecology? If so, how do we do it? How do we assess the pros and cons of such ideas as damming Long Island Sound, waste disposal by deep-well dumping, building a fleet of SST's, digging a new sea-level Panama Canal, or developing automated teaching aids?

What we are seeking here at the moment is not the answer to any given problem, but a permanent, efficient mechanism which will help us gauge these things, help us balance the good in technology against the evil, and do it before we have so much invested that it is not economically feasible to break off or that the physical effects of the new technology have become irreversible.

If and when we develop such a mechanism, I believe we will have a new and important element added to our science policy.

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